Leviathan Biomonitoring TAC Update
January 2017

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Summary of trends in **bioassessment** monitoring of benthic macroinvertebrates 1998 - 2015

Based on contrasts to similar **reference streams** (matched for size, elevation, geology)

Including metals analysis and relationship to biological indicators and **potential targets for attaining recovery**

Water quality indicators:

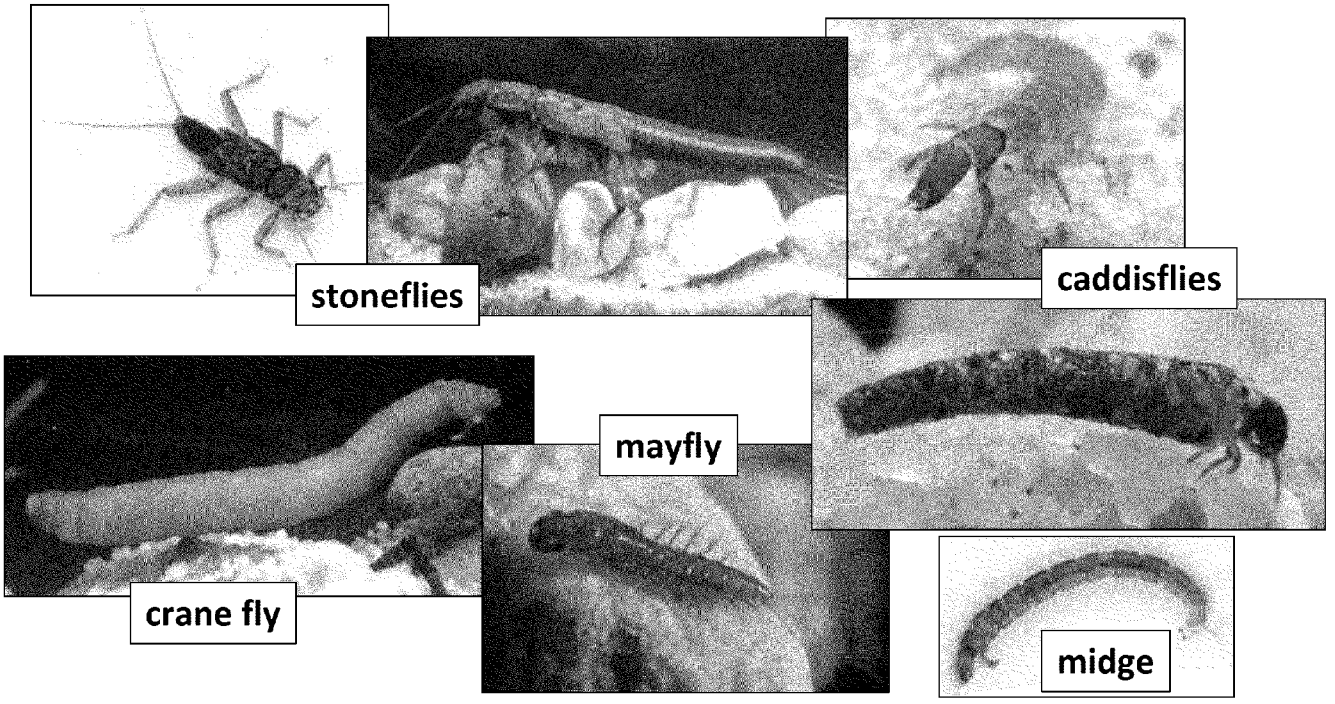
>Diversity of life present, esp. of sensitive insects =EPT

>Tolerance of members of the community to pollution

>Density of organisms present (forming the food web)

>Changes with season, year, management & hydrology

>Comparisons of AMD-affected sites to references/controls



Biomonitoring Surveys at Leviathan Mine streams: Using stream invertebrates to measure aquatic ecosystem recovery and responses to AMD metals and treatment remediations

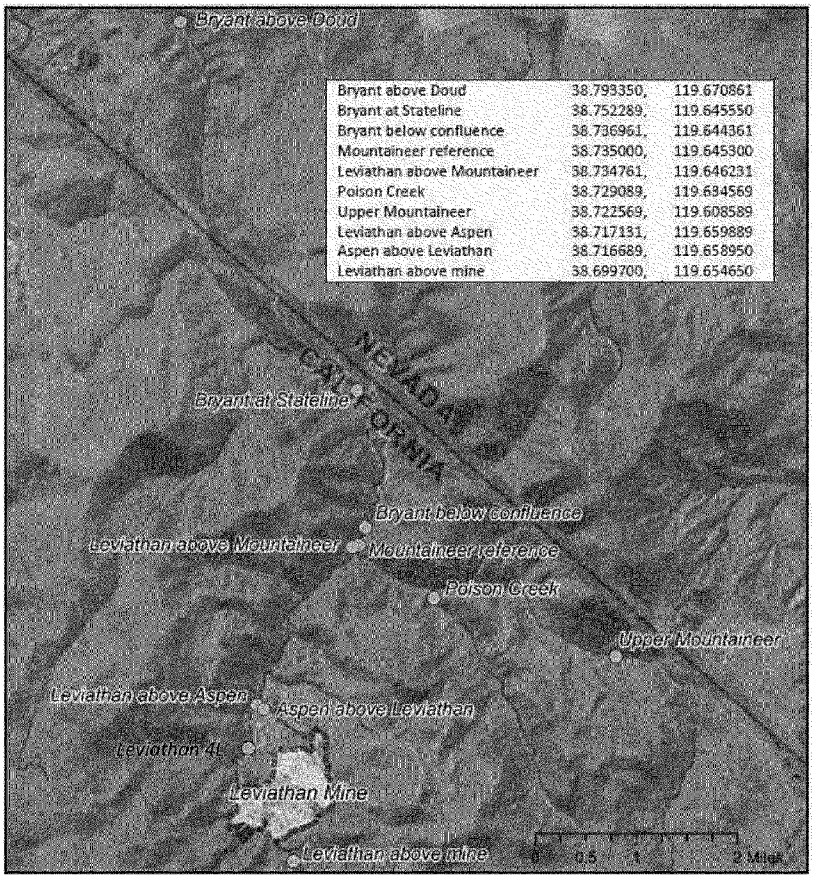
- **Seasonal sampling in spring (June) and fall (September) for trends at beginning and end of treatment period**
- **Samples each site from replicated collections in riffle habitats using a D-frame net (lab IDs/counts >1500 each)**
- **Used throughout California for stream monitoring**
- **Coupled with metals chemistry of water and sediment**
- **Why? Provide support for knowing how remediation works to improve water quality and health of aquatic life and relation to levels of metals contamination**

Where? Leviathan/ Bryant Creek Watershed sample sites

In addition to Mountaineer as primary local no-AMD reference, other reference sites in the <u>East Carson watershed include:</u>

- **Upper Mountaineer**
- **Leviathan, above mine**
- **Poison Crk**
- **Cottonwood Crk**
- **Monitor Crk**
- **Dixon Crk**
- **Snodgrass Crk**

These match similar geology, geography, size and setting



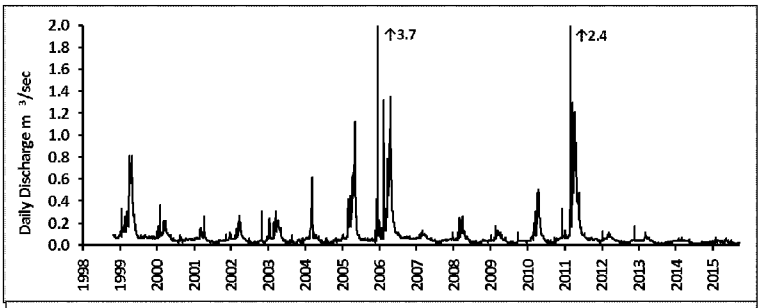
Bryant above Doud	38.793350,	119.670861
Bryant at Stateline	38.752289,	119.645550
Bryant below confluence	38.736961,	119.644361
Mountaineer reference	38.735000,	119.645300
Leviathan above Mountaineer	38.734761,	119.646231
Poison Creek	38.729089,	119.694569
Upper Mountaineer	38.722569,	119.608589
Leviathan above Aspen	38.717131,	119.659889
Aspen above Leviathan	38.716689,	119.658950
Leviathan above mine	38.699700,	119.654650

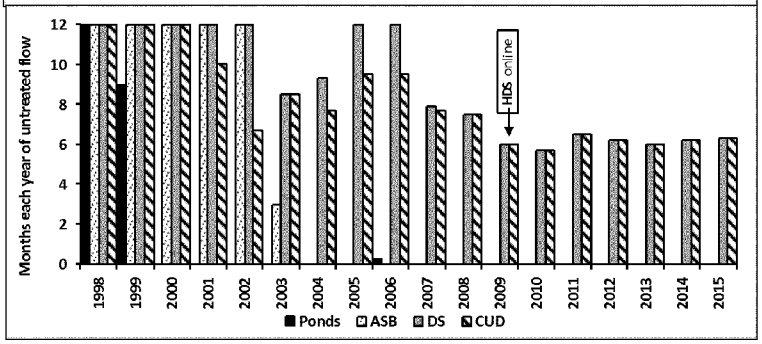
Hydrograph >

Remedial Treatments

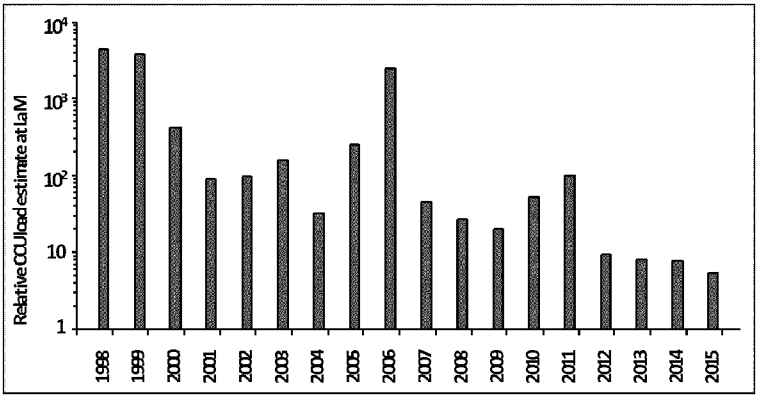
Relative Metals Load

- High flows 2005-06 and in 2011
- Drought 2012-15 and in 2007
- Improving capture and lower loads over time except high flow (note log scale)



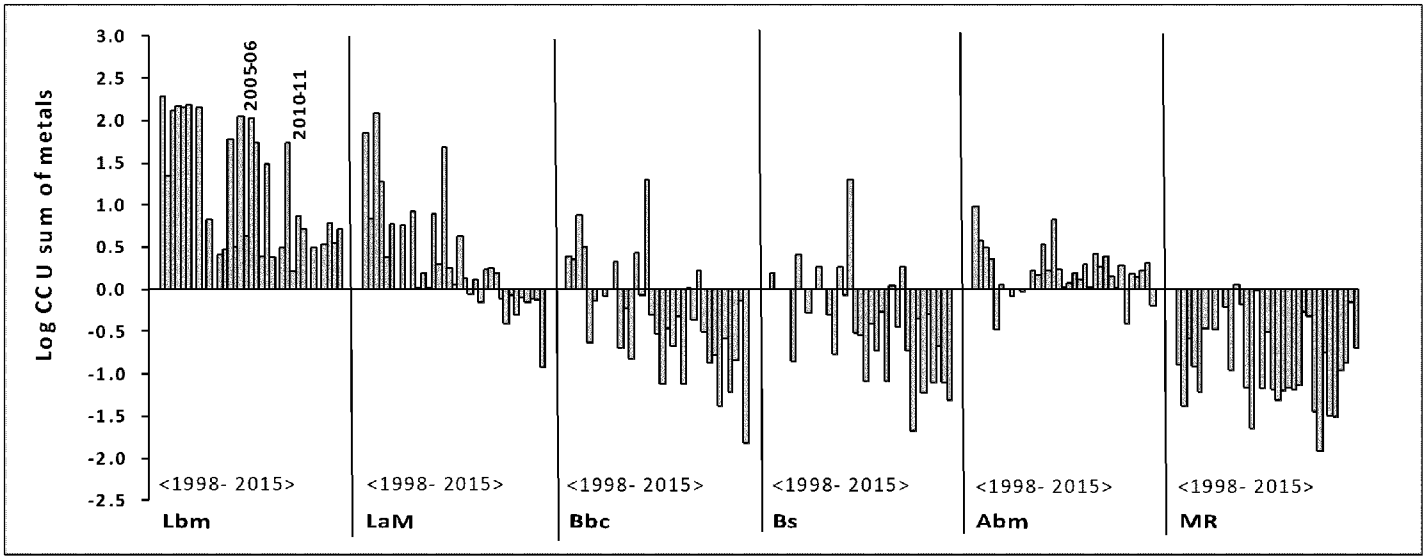


Log Scale



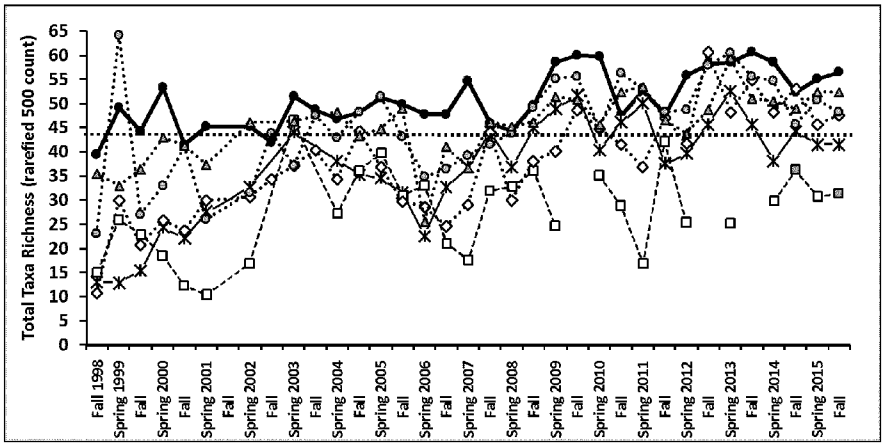
Expressing metals concentration in terms of toxicity to aquatic life: cumulative criterion units

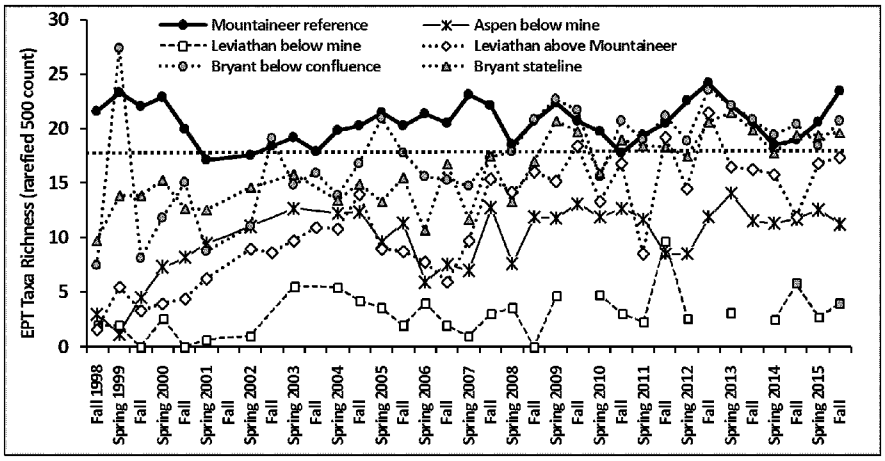
- **Physiological measures of concentration resulting in mortality to selected test organisms, eg LC50**
- **Sum over all metals present; 8 primary at Leviathan = Al, As, Cu, Fe, Mn, Ni, Se, Zn**
- **CCU = 1 is the expected level for toxic effects (log 1 = 0)**



Biomonitoring trends 1998-2015: Diversity

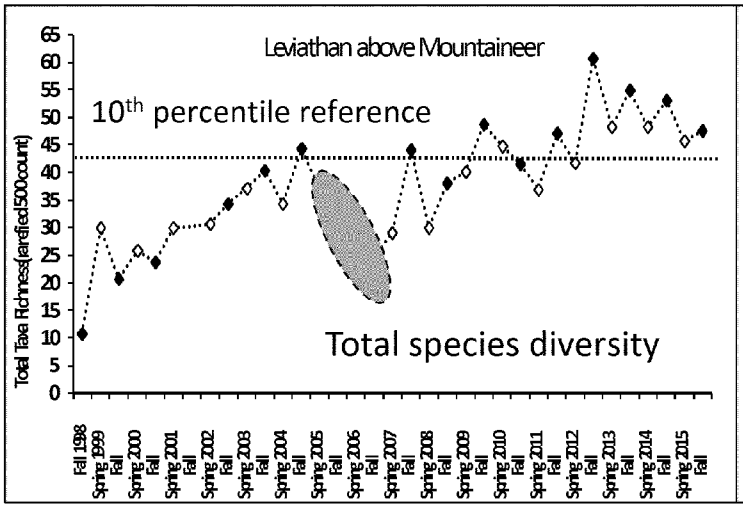
- Dashed lines: 10th percentile of all reference streams (CA standard)
- Recovery progress is more complete when all species are plotted than just the more sensitive EPT
- Bryant recovered by both measures but other sites not yet attaining reference for the EPT diversity

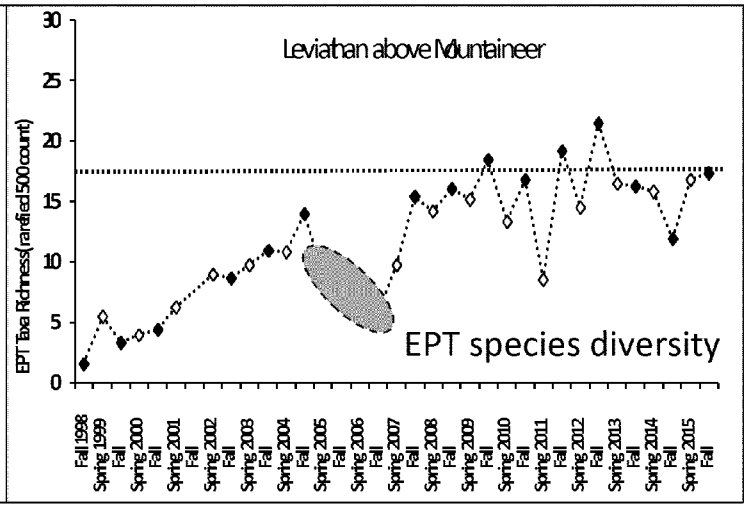




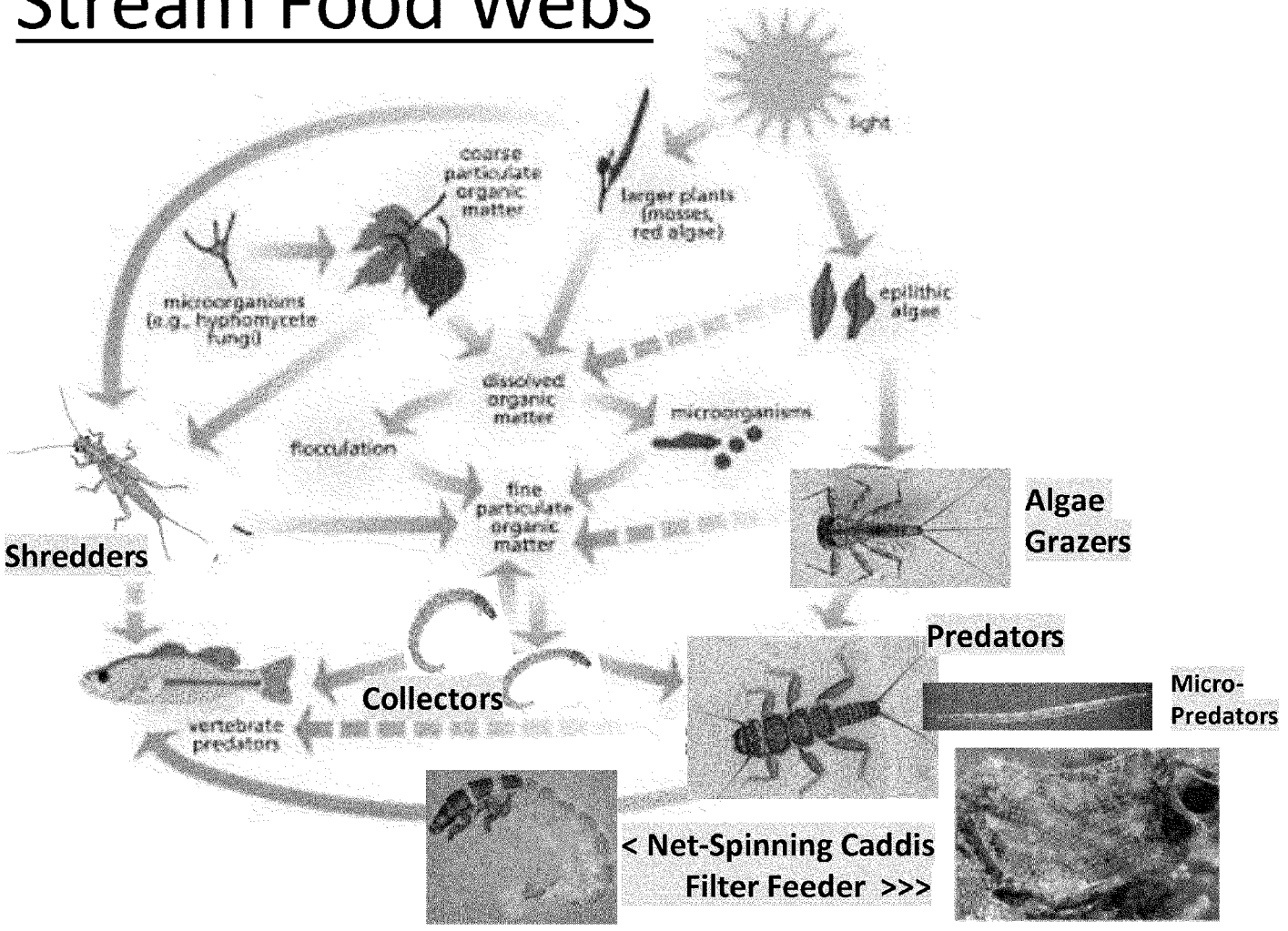
Seasonal recovery and relapse: metals higher and diversity lower in spring >> metals lower and diversity higher by fall

- **Leviathan above Mountaineer integrates AMD sources from Leviathan and Aspen but not diluted by Mountaineer Creek = used as an index site**
- **Lower diversity in spring (open ◊), increasing by fall most years (dark♦)**
- **Total & EPT diversity improve over time but in most years there is a seasonal relapse and recovery pattern except in high load years (early yrs and 2005-06)**
- **Metals high in spring after overwinter period without treatment, and reduced by fall of each year after summer capture and treatment**





Stream Food Webs



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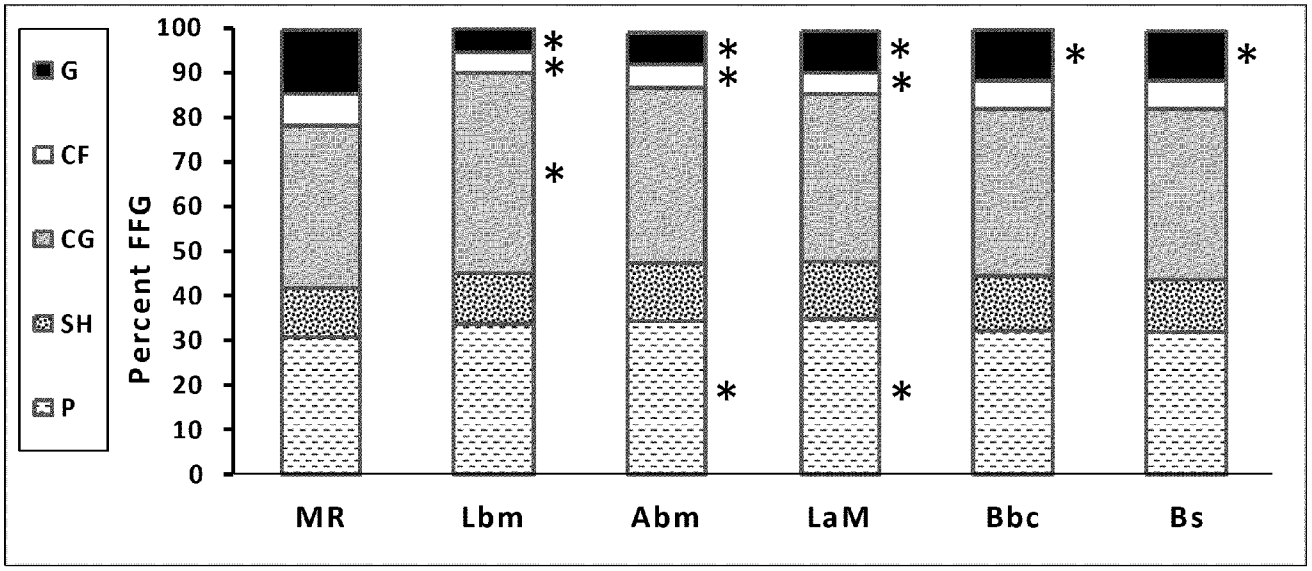
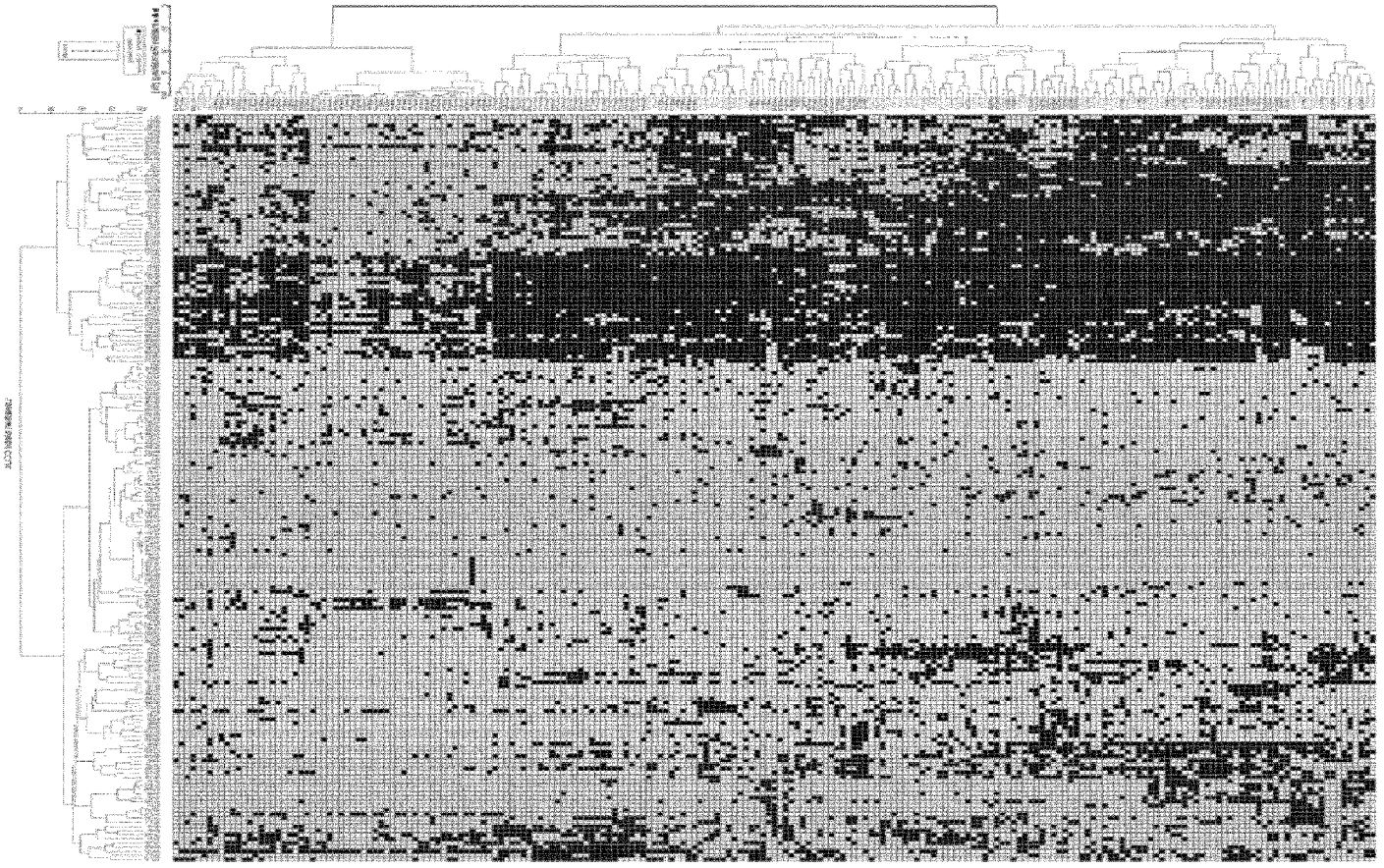
How do the stream sites differ in the type of food web present?

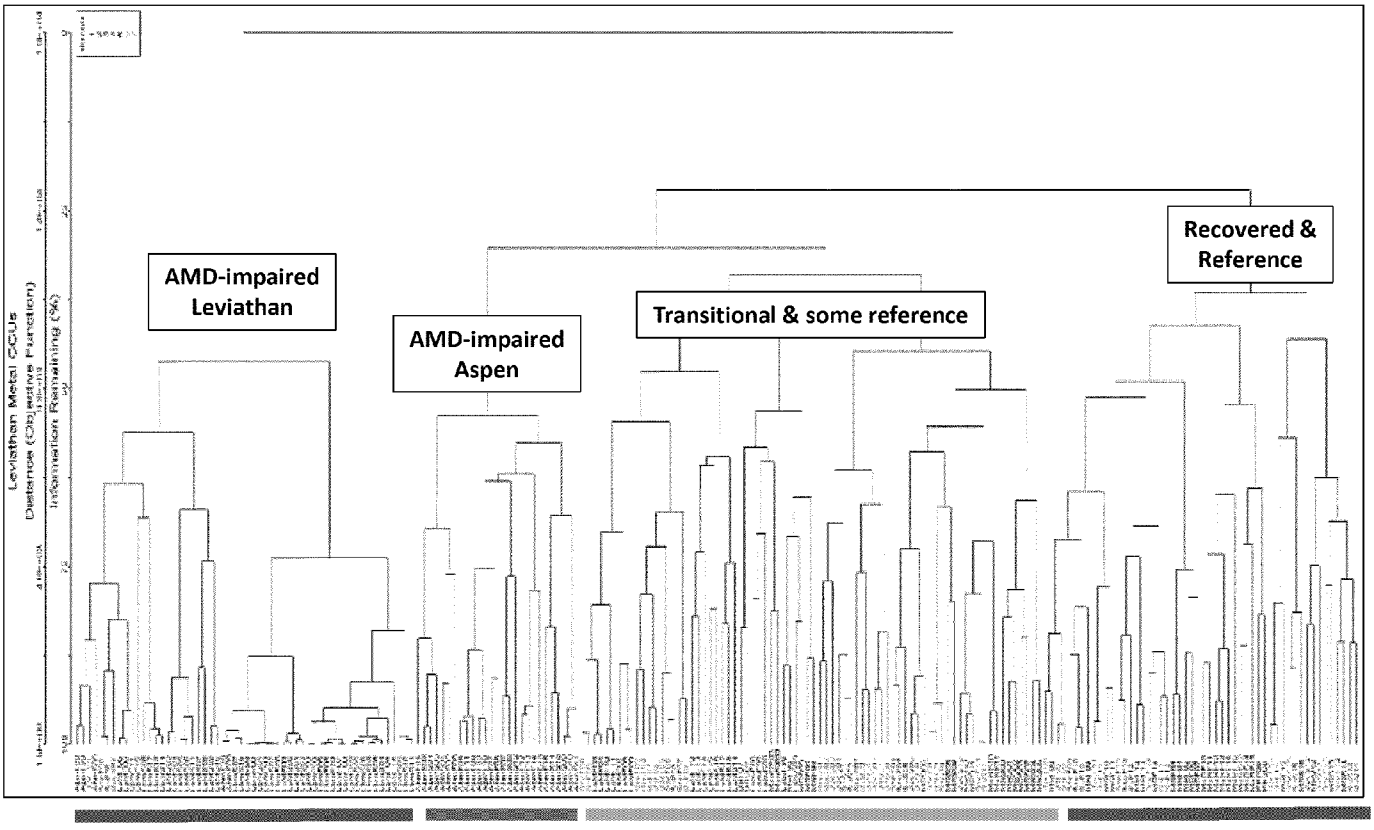


- **Grazers of algae (G) and collecting filterers of suspended organic particles (CF) are reduced by AMD**
- **Gatherers of organic deposits (CG), mostly midges, greater at Lev below mine, and small predators (tolerant biting midge larvae) greater percent in Aspen & Lev abv Mtneer**

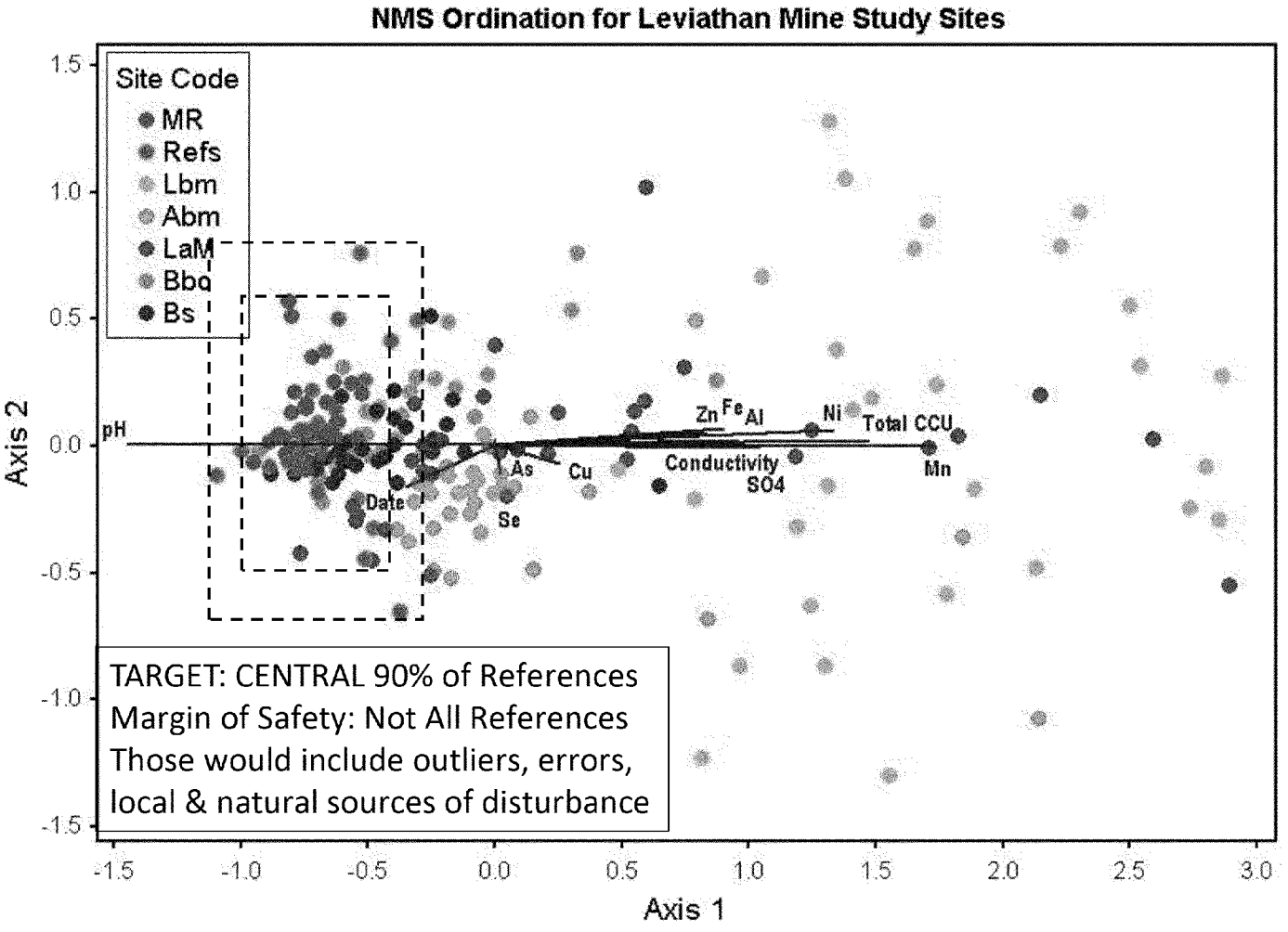
“Fingerprint” of species X site



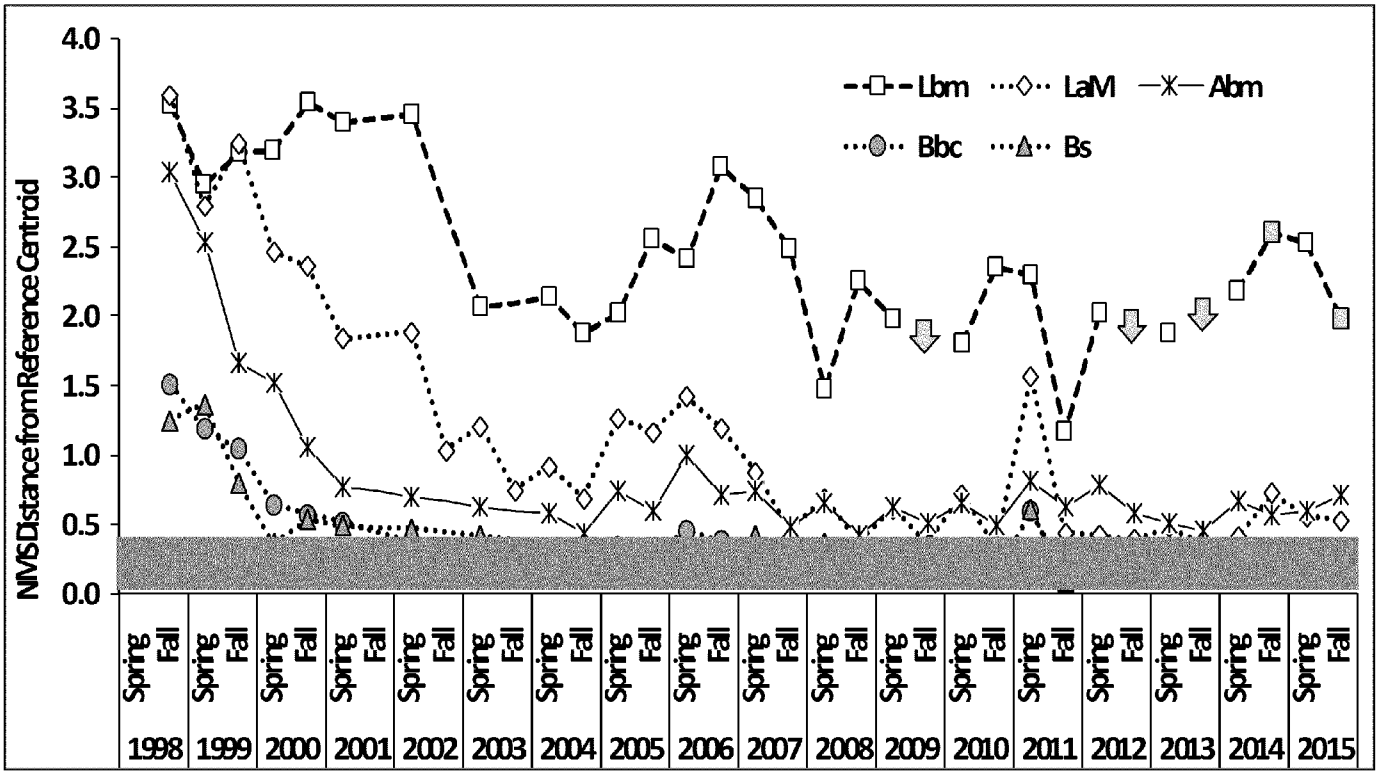
“Fingerprint” of site biological similarity



Leviathan below mine Leviathan above Mtneer	Aspen	Mixed Bryant, Lev abv Mtneer, some external references	Bryant, Mountaineer, other references


NMS Ordination for Leviathan Mine Study Sites
Site Code
MR
Refs
Lbm
Abm
LaM
Bbq
Bs
pH
Zn
Fe
Al
Ni
Total CCU
As
Cu
Conductivity
SO4
Mn
Date
Se
TARGET: CENTRAL 90% of References
Margin of Safety: Not All References
Those would include outliers, errors,
local & natural sources of disturbance
Axis 2
Axis 1
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0

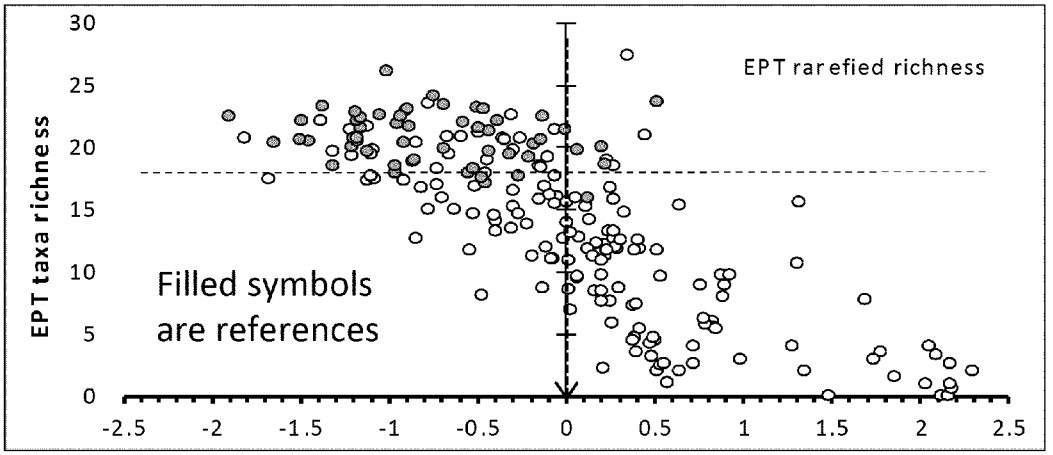
Advance towards recovery of reference community structure

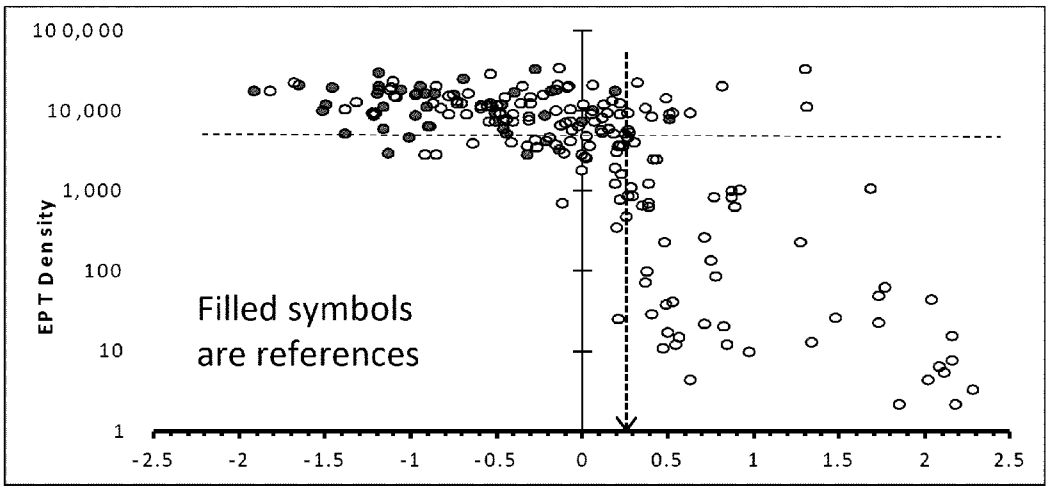


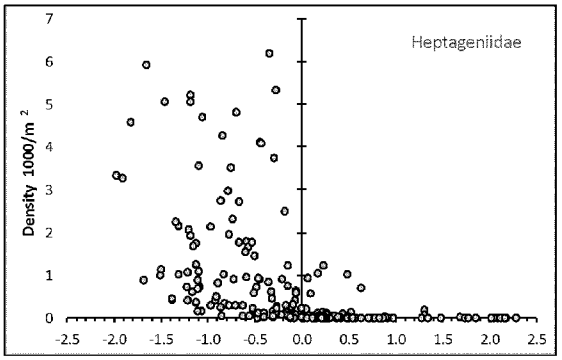
Effect Level Responses to Metals CCU

Examples:

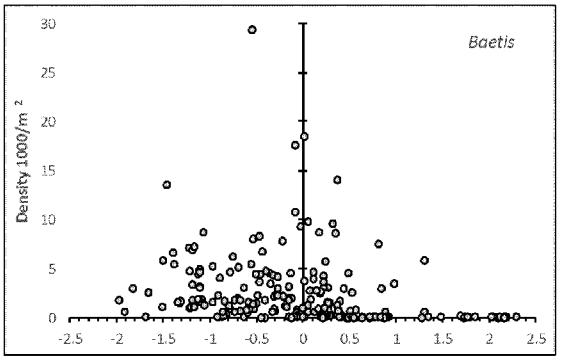
- **EPT diversity**
- **EPT density**
- **>10th %tile reference is acceptable (CA standard)**
- **90th %tile of CCU values meeting the standard =**
- **Effect level, near CCU =1**
- **Observed matches predicted**
- **Indicates target level for control of metals**





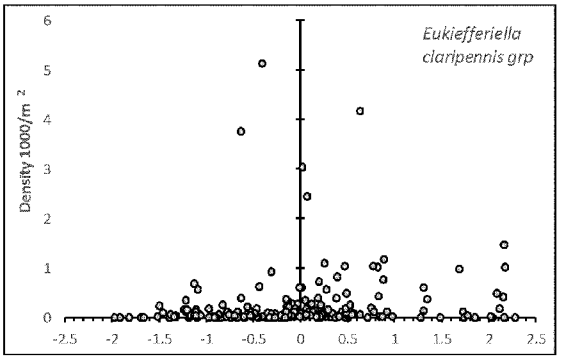


SENSITIVE



INTERMEDIATE

TOLERANT



Examples of species responses

Summary of Long-Term Monitoring

- **Seasonal patterns show that recovery often occurs by fall, near the end of the treatment season, but with exposure to untreated AMD when treatment ends, there is relapse and return to an impaired ecological state by the following spring (shows the need for both spring & fall sampling to demonstrate full recovery)**
- **Seasonal loss of integrity does not occur at reference sites**
- **Declining trends in metal CCUs parallel improving biological health and demonstrate effectiveness of treatments**
- **Bryant sites appear recovered to reference state**
- **Sites nearest mine and Leviathan above Mountaineer remain below reference EPT, but LaM approaching reference community**
- **Food web is altered by AMD, limiting proportions of rock-surface groups such as grazers and filter feeders (densities also lower)**
- **Ecological indicators show metal effect level near expected CCU=1**
- **2016 Spring sample identifications completed; Fall 2016 underway**